

Cycle: Low Learning of Middle School Math
--> Low Knowledge of Math of Middle School Math teachers
--> Low Learning of Middle School Math
--> ... --> ... --> ... --> ...

By Dr. Jerome Dancis (Associate Professor Emeritus of mathematics, UMCP)
Presented to the MD State Board of Education, April 26, 2010

"Breaking the Cycle: An International Comparison of U.S. Mathematics Teacher Preparation"; this report (on US TEDS-M) is at <http://usteds.msu.edu>; press release at http://media-newswire.com/release_1116649.html

"U.S. Falls Short in Measure of Future Math Teachers" (New York Times, Published: April 14, 2010) Excerpt:

"The [Breaking the Cycle ...] study reveals that America's middle school mathematics teacher preparation is not up to the task," said William H. Schmidt, the Michigan State University professor who was its lead author.

... In the study, a representative sample of 3,300 future math teachers nearing the end of their teacher training at 81 colleges and universities in the United States were given a 90-minute test covering their knowledge of math concepts as well as their understanding of how to teach the subject.

There were two distinct tests, for those preparing to teach in elementary schools and for candidates for middle school.

The same tests, developed by an international consortium, were given to college students in 15 other countries, including advanced nations like Germany and Norway as well as underdeveloped ones like Botswana." [END NY Times excerpt.]

Nations' middle-school-students' average score on TIMMS math exam correlates with nations' about-to-graduate-college-senior, future-middle-school-math-teachers' average score on study's math exam. U.S. in middle of both rankings. There is a wide disparity among colleges in the U.S.

More comments at: www.joannejacobs.com/tag/william-schmidt Excerpt:

"William H. Schmidt, the Michigan State University professor, its lead author: "A weak K-12 mathematics curriculum in the U.S., taught by teachers with an inadequate mathematics background, produces high school graduates who are at a disadvantage. When some of these students become future teachers and are not given a strong background in mathematics during teacher preparation, the cycle continues."

In releasing the Breaking the Cycle report, Schmidt said that more rigorous common core standards "will require U.S. math teachers to be even more knowledgeable." His study found that while nearly all future middle-school teachers in the top-achieving countries took courses in linear algebra and basic calculus, only about half of U.S. future teachers took the fundamental courses."

Jerome Dancis: At press release, I said that calculus is *not* necessary for middle-school math teachers, but high school chemistry and physics would be very useful – also having a combined math and science middle school certification.

College Readiness -- A Simple Description

By Jerome Dancis, Associate Professor Emeritus, Math Dept., Univ. of MD
Math Education Website: www.math.umd.edu/~jnd

Ready for college. To survive academically the first year of college, students basically need the three Rs, Reading, Writing and Arithmetic, albeit all on high school levels.

Reading means reading *with* understanding the expository and descriptive text in science and social studies textbooks, *not* literature. Writing means writing a coherent summary of each chapter in the science and social studies textbooks. Arithmetic means Arithmetic, including fractions, decimals, percents, measurement and multi-step Arithmetic word problems, along with “generalized” Arithmetic, better known as Algebra.

1. Mathematics.

Low level College-ready Math Standard. Graduates should be fluent in Arithmetic and real (1980's) high school Algebra I, without calculators. Also, competency with spread sheets would be useful – but not mentioned in Common Core.

Some might consider it unfair to require Grade 8 students to add fractions, when many states do *not* require this of middle school Math teachers.

Fully college-ready Math Standard: To be ready for any Science, Technology, Engineering and Mathematics (STEM) major in college a graduate needs to be fluent in Pre-Calculus. This, in turn requires fluency in Arithmetic and Algebra II. A grade of C is *not* sufficient; depending on curriculum and teachers' standards, a grade of B (or even A) may *not* be sufficient. My guess is that a score of 600 on the Math SAT and on the SAT II advanced math exam are necessary, but not sufficient, for success in college calculus (for engineers).

Adding the Arithmetic and Pre-Algebra Math SAT and PSAT questions to the middle school Math curriculum would be a good step toward making all students more college ready. This would also make 600 a reasonable goal for the average score of a state's graduates on the Math SAT. The following problem was rated a 3 (out of 5) for difficulty by the SAT. Instruction for such problems usually is *not* included in the Math curriculum.

An SAT Problem. "How many minutes are required for a car to go 10 miles at a constant speed of 60 miles per hour?"

Warning. Unfortunately, Probability and Statistics is a major strand in the middle and high school part of the March draft of the Common Core Math Standards. But, Probability and Statistics are NOT necessary for college readiness. Freshmen, with a 5 on AP Statistics exam, and a C in high school Pre-Calculus, wishing to major in statistics (in college) will be *at-risk* in this major. Freshmen, with **zero** K-12 Statistics, but aced high school Pre-Calculus are fully ready to major in statistics. (The first college Statistics course, for students majoring in engineering or statistics, is based on calculus; it makes AP Statistics look like child's play.)

High school ready in Math for rigorous high school chemistry and physics classes requires fluency in Arithmetic including (*) measurement and (*) multistep word problems, as well as on (*) fractions, decimals and percents and on (*) units and proportions. Also required is automaticity on decimal equivalents of percents and fractions.

NOT in the March draft of the Common Core Math Standards for middle school.

High school ready in Math for high school personnel finance classes requires fluency in decimal equivalents of percents and fractions.

NOT in the March draft of the Common Core Math Standards. For example, memorizing that 50% equals a half, or even being able to figure out that 50% equals a half or .5 are NOT included.

In sharp contrast: "As his [Grade 5] students lined up after lunch outside his classroom, he popped questions before they could enter. "Kayson, what is two-fifths as a percent?" he asked. The boy hesitated before correctly answering 40. "Next time," Mr. Skeeter said, "quicker."

www.nytimes.com/2010/05/02/education/02charters.html?sq=charter%20schools&st=cse&scp=2&pagewanted=print

College math professors are *distressed* by the low level of understanding of arithmetic and arithmetic-based Algebra by masses of college students. This is why the MD/DC/VA SECTION of the Mathematical Association of America (MAA) has broken tradition by issuing its first statement ever on the College Professors' Concerns on Mathematical Preparedness of Incoming College Freshmen

[http://www.salisbury.edu/mddcvamaa/HS_students.asp]. I paraphrase its key recommendation as: Students should be able to perform basic calculations in Arithmetic and in Algebra, without the assistance of calculators. Thus, the Algebra I, needed for college, is largely *excluded* from the MD HSA on Algebra.

Also see my reports "**Comments on Statement on Mathematical Preparedness**" as well as my "**Notes on Remedial Math Problem**" and "**A Review of the Report of the Task Force on the Education of Maryland's African-American Males -- Useful Initiatives that should have been included**" on my **Math Education Website**.

2. Literacy

Goal for English classes Grades 4-12 should be that students can understand their science and social studies textbooks and be able to write a coherent summary of each chapter (one page or less). This would require *replacing* perhaps half of the literature in these English courses with paragraphs from their science and social studies textbooks. Proficiency in literature is important, but it is *not* necessary for college readiness.

Writing and Speaking. Student need to be able to write and speak paragraphs coherently, clearly, concisely, comprehensively, logically, accurately and precisely without being cryptic, vague, ambiguous, obscure, redundant or repetitive. This needs to be made a main focus of English and social studies classes in Grades 4-12.

Also see: "Literacy (writing and reading) is crucial" on my website at www.math.umd.edu/~jnd/Literacy.htm.

Our children deserve a better instructional program.

Lesser notes:

"Along a wall [of the Dundalk campus of the Community College of Baltimore County's Student Success Center] is a rack of handouts explaining points of grammar that might have last been explicitly taught in middle school, a measure of the immense ground to be made up. One covers comparative adjectives, explaining "more" vs. "most" or "smarter" vs. "smartest." Another discusses using pronouns and verb tenses." ["At 2-Year Colleges, Students Eager but Unready", N. Y. Times, Sept. 2, 2006 www.nytimes.com/2006/09/02/education/02college.html?_r=1&sq=McKusik&st=nyt&scp=1&pagewanted=print]

Ezra Shahn wrote ["On Science Literacy," in Educational Philosophy and Theory. Journal of the Philosophy of Education Society of Australia, (1988).]: "In descriptions of many biological phenomena ... 'understanding' means mastery of a sequence such as A then B then C then D It was as though in reading or hearing 'then' the student was understanding 'and'. ... [But] the sequential relationship is more restrictive, hence more precise and it is this distinction that many students apparently fail to grasp." Shahn also wrote: " ... it seems that students often misread conjunctions [including the implication words 'because' and 'then' (as in 'A then B')]] so that they mean 'and'. "

Arnold Arons [A guide to introductory physics teaching, Chapter I Underpinnings, Section 1.16 Language] wrote: "... essentially the same problem frequently arises in connection with 'if ... then' statements of reasoning." Arons elaborated: "Crucial to understanding scientific reasoning and explanation [in beginning physics classes] as opposed to recall of isolated technical terms, resides in the use of [implication words] words such as 'then' and 'because'.

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The Arithmetic part of a two-line calculation in a Chemistry textbook [Zumdahl, 5<sup>th</sup> edition]:

Simplifying the following messy fraction [where "^" denotes an exponent]:

$$\frac{(1.0 \times 10^{-1}) (1.0 \times 10^{-2})^2}{(2.0)^2 (0.50)^4} = 4 \times 10^{-5}.$$

Students should be able to simplifying this quickly, without a calculator, mostly doing mental math. This type of Arithmetic calculations is not part of the high school math curriculum; it belongs in middle school math, then will be reviewed and practiced in high school science classes.

## Common Core Math Standards – Much Good, Much Bad, Much Importance

by Jerome Dancis, Department of Mathematics, University of Maryland

### Presented at VA/DC/MD section of MAA Spring 2010 meeting

March 2010 draft at [www.corestandards.org/Files/K12MathStandards.pdf](http://www.corestandards.org/Files/K12MathStandards.pdf)

I have browsed the Common Core Math Standards; these are some of my impressions.

The Common Core Math Standards are *supposed* to be minimally college and “career” ready standards (**no** need for college remedial courses), which are “World Class”. This draft includes a statistics and probability strand in middle and high school, even though zero knowledge of statistics and probability is required (by colleges) for freshmen to be college ready. In fact, zero knowledge of statistics and probability is required of college freshmen pursuing a major in statistics and probability.

After outcry, math standards were added, just for students expecting to major in Science, Technology, Engineering and Mathematics (STEM).

These standards are also supposed to be “higher, clearer and fewer”. My impression is the K-8 math standards are higher, clearer and fewer than those of the bulk of the states. But, they need to be even higher, clearer and fewer. Possible that Massachusetts’ current Math standards are better.

**Much Importance:** 41 states have adoption “on calendar”.

U. S. Dept. of Education’s Blueprint (for replacing NCLB) proposes mandating a utopian goal of 100% [minimally] **college ready** by 2020. Many states will likely choose the Common Core Math Standards as their college ready standards. (More info in “[Education Reform 101](http://www.americanprogress.org/issues/2010/03/education_reform101.html) -- A Primer on the New Elementary and Secondary Education Act” [www.americanprogress.org/issues/2010/03/education\\_reform101.html](http://www.americanprogress.org/issues/2010/03/education_reform101.html))

**Standards matter.** Nearly all state standards after 1990 were modeled on the 1989 *NCTM Standards*. [“**Computation Skills, Calculators, and Achievement Gaps: An Analysis of NAEP Items**” Tom Loveless, The Brookings Institution, April 2004]

The 1989 NCTM standards state: “This is not to suggest that valuable time should be devoted to exercises like  $(17/24) + (5/18)$  or  $5\frac{3}{4} \times 4\frac{1}{4}$ . ... “Division of fractions should be approached conceptually”. It called for marginalizing arithmetic and emphasizing superficial statistics.

**Algebra Ready [NOT]** “Rational numbers and operations involving fractions and decimals” was rated as the second worst in terms of student preparation, by the national survey of Algebra teachers performed for the rigorously researched National Advisory Mathematics Panel in 2007. This report NOT listed in “Sample of Works Consulted” by Common Core.

For the 17 year olds, (nationally) a dramatic decline in learning fractions --, from scoring 76% in 1990 to 56% in 1999 (on NAEP questions).

Read my article, “More Remedial Math? [YES]” in March 2010 UMD Faculty Voice.

## **Decline in Percent of MD HS Graduates Minimally Ready for College Math when they entered a College in MD.**

|                   | <u>1998</u> | <u>2005</u> | <u>2006</u> |
|-------------------|-------------|-------------|-------------|
| Whites            | 67%         | 60%         | 58%         |
| African-Americans | 44%         | 33%         | 36%         |
| Asian-Americans   | 79%         | 74%         | 76%         |
| Hispanics         | 56%         | 42%         | 43%         |

**Much GOOD.**

1. #10. Solve systems of two linear equations in two variables algebraically, ...
  - #11. Solve and explain word problems leading to two linear equations in two variables.
- Grade 8

This part of #10 suggests that Grade 8 contains significant Algebra I. Certainly, far **more** than the standards of MD. Knowing that  $3x + 2x = 5x$  is **not** on the syllabus for MD state [HSA] exam on [Some concepts in] Algebra and Data Analysis.

It even has this “higher level” problem in high school:

“16. Solve algebraically a simple system consisting of one linear equation and one quadratic equation in two variables; for example, find points of intersection between the line  $y = -3x$  and the circle  $x^2 + y^2 = 3$ . “

But, *postponed* to HS: “Understand that given a system of two linear equations in two variables, adding a multiple of one equation to another produces a system with the same solutions. This principle, ... allows for the simplification of systems.”

But, **NOT to focus on** (in HS): Solving 3 linear equations in 3 unknowns.

2. Definitions in math are often based on extending and preserving an important rule, definitions are *not* based on any simplistic rationale.

Common Core Grade 7 Standards include that students will be required to know that it's “the distributive law, [that leads] to products such as  $(-1)(-1) = 1$ ” YEA

These are real Algebra I topics. In contrast, the Algebra on the MD HSA on Algebra is mostly Grade 6 level Algebra background. This is beyond the Algebra knowledge of many middle school Math teachers, with full K-8 certification, including the MSDE endorsement as a “highly qualified” middle school Math teacher.

Gene Wilhoit, Executive Director, Council of Chief State School Officers, said this is true nationally.

To receive certification as an *elementary* school teacher, applicants must pass a state licensing exam; prospective teachers may skip the Arithmetic questions and still pass (by scoring well on the other questions). New exception: Massachusetts now requires

prospective teachers to pass a math exam. Read: "Making the grade: New math standards for teachers" at

[www.boston.com/bostonglobe/editorial\\_opinion/oped/articles/2009/09/09/making\\_the\\_grade\\_new\\_math\\_standards\\_for\\_teachers/](http://www.boston.com/bostonglobe/editorial_opinion/oped/articles/2009/09/09/making_the_grade_new_math_standards_for_teachers/)

**3. Fractions.** "The often-difficult subject of fractions is developed beautifully, with clear and careful guidance.... Sometimes the standards' specificity is almost at the level of a textbook, as with the development of fractions.... Formulas for the arithmetic of fractions are rarely, if ever, derived in standards. Common Core's work here is path breaking."

From Fordham (JHU Math Prof Steve Wilson) report. Grade of A- for math standards.

[http://edexcellence.net/index.cfm/news\\_review-of-the-draft-k-12-common-core-standards1](http://edexcellence.net/index.cfm/news_review-of-the-draft-k-12-common-core-standards1))

The California Math Framework also contains a good development of mathematics, including fractions.

[BUT]

"Understand that division of fractions is defined by viewing a quotient as the solution for an unknown-factor multiplication problem. For example,  $(2/3) \div (5/7) = 14/15$  because  $(5/7) \times (14/15) = (2/3)$ ."

Students actually dividing  $2/3 \div 5/7$  is NOT in standards.

Univ. of Maryland lead calculus teacher, Denny Gulick is aghast that the word "Understand" appears 207 times.

Many of the "understand" standards are paired with the "compute", "find" and "solve" standards; many are NOT. OK

"Know from memory" is *limited* to the addition & multiplication tables.

The many other memorization standards in previous draft were converted to understand standards. BOO

4. Omitted: Pattern mis-recognition; these are mathematically WRONG. BIG YEA  
MD state [HSA] exam on [Some concepts in] Algebra and Data Analysis:

"Sample B Look at the pattern below.

0, 2, 4, 6, 8, ...

If the pattern continues, what will be the next term? "

Omitted: Prob & stat in K-5 BIG YEA Time reallocated to Arithmetic.

Omitted: mode -- an often *misleading* concept, also *undefined* in real life.

### Much BAD

#### 1. Omitted:

Spread sheets & Deciles. BOO

Converting  $1/3$ ,  $1/20$ ,  $1/1000$  into decimal notation.

Knowing that 50% equals a half.

Knowing that a million is a thousand thousands.

### Calculations in Gen Chem

How big a problem in 1st yr chem. is math background: Major, minor, or none.

Vote of 25 college chemistry educators was "major" - 100%.

What's the most important background knowledge needed for Gen Chem: calculator use, math theory, or math computation. Their vote was computation, 100%.



From presentation on math computation to 25 college chemistry educators at the American Chemical Society regional meeting in Wilmington. The powerpoint slides are at [www.ChemReview.Net/MarmPost.ppt](http://www.ChemReview.Net/MarmPost.ppt)  
Or access from [www.ChemReview.Net](http://www.ChemReview.Net) at the MARM tab on the left.

2. Ready for rigorous high school chemistry and physics classes. NOT Automaticity on decimal equivalents of percents and fractions. Need to beefed up middle school standards on (\*) measurement and on (\*) multistep word problems, as well as on (\*) fractions, decimals and percents and on (\*) units and proportions.

### **Financial Literacy**

**Problem.** You borrow \$100; you agree to pay ten percent interest. How much interest do you pay?

Blair HS Teacher (Montgomery County) estimates this will stymie 65% of his students.

You will see on my classroom board a simple lesson and diagram that I teach and re-teach about 5 times a year in business class that converts a fraction into a decimal and then reformats that number with a percent sign.

### **Trigonometry STEM & Basic Laws of Logarithms & Exponentials**

U MD Math Prof. Denny Gulick wants **instant recall** of Famous Trig identities (by students, who have taken a Trig course).  
Famous trig identities NOT mentioned.

U MD Math Prof. Denny Gulick wants **instant recall** of basic laws **Logarithms & Exponentials**.

Instead, merely: "STEM Relate the properties of logarithms to the laws of exponents and solve equations involving exponential functions."

But, there is: "Understand that the definition of the meaning of zero, positive rational, and negative exponents follows from extending the laws of exponents to those values, allowing for a notation for radicals in terms of rational exponents." YEA

"Rewrite expressions using the laws of exponents. For example,  $(x^{1/2})^3 = x^{3/2}$  and  $1/x = x^{-1}$ ."

### **"World Class" NOT close**

**Problem.** (Singapore Math Grade 5 *Arithmetic* problem) "Encik Hassan gave  $2/5$  of his money to his wife and spent  $1/2$  of the remainder. If he had \$300 left, how much money did he have at first?"  
A simple Arithmetic (no Algebra) solution is in <http://math.coe.uga.edu/tme/issues/v14n1/v14n1.Beckmann.pdf>

### **Connections.**

The standards do not include (\*) the many useful connections between topics as well as (\*) combinations of topics, even  $1/3 - 1/6 + 1/4$  is omitted. These connections are needed for a coherent curriculum. Requiring multi-step problems, involving two or more standards, will make rote instruction and rote learning less feasible!

**Fragmentation.** Learning to add fractions is split between Grades 4 and 5. Memorizing the multiplication table is split between Grades 3 and 4.

U. Minn. Math Prof. Bert Fristedt wrote (in an open letter): ... the Common Core Standards] are not usable [by textbook & exam writers and by teachers]. .... If textbook writers try to use them the result is likely to be overly long fragmented textbooks. Their use by teachers ... can cause math to seem like a long sequence of somewhat unrelated tasks.